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RADIOGRAPHY AS AN AID TO DIAGNOSIS.

BY J. HALL-EDWARDS, L.R.C.P., F.R.P.S.

DURING the last few weeks so much has been written descriptive of the apparatus, and the various methods of producing radiographs that it is unnecessary for me to enter into further details, any more than to mention the causes, which have brought about the infinitely superior results of to-day, as compared with those of a few weeks back. The most important advance has been made in the construction of the necessary tubes. In the first experiments, when the excitement caused by the discovery was at its highest pitch, every available radiant matter tube was seized upon, and, as the demand was greater than the supply, a different form of tube was used, by each investigator, with varying results. It was soon found, however, that some forms were superior to others, and that the results obtained depended not only upon the degree of vacuum, but upon the shape of, and materials used in the construction of the poles, and upon the glass used in the manufacture of the tubes. Some makes of glass are vastly superior to others, lead glass being nearly useless. The chief advance in tube manufacture appears to have been the outcome of a suggestion, which originated with Mr. Herbert Jackson, of King's College. In this (so-called)

"focus tube" the Cathode pole consists of a concave disc of aluminium, which when in use concentrates the rays upon a square of platinum, attached to the Anode pole. This piece of platinum is fixed at such an angle that it reflects the Cathode rays upon a certain small area of the glass of the tube. In this tube—which is stated to have been designed by Prof. Crookes in 1877—we certainly have an instrument which yields better results, in a shorter space of time, than any previously put upon the market. This form of tube (with small modifications) is now in general use), and it is stated that Prof. Röntgen himself has adopted it.

The question as to whether the term "focus" applied to this special form of tube is correct, is not a matter which can be discussed in a journal devoted to medical science; still I cannot refrain from stating that in my humble opinion it is inaptly applied. The superior results are brought about, in the first place, by the fact that the surface from which the X rays emanate is lessened, hence less distortion is produced; and in the second, that owing to the vacuum being more complete, the tubes can be placed at a greater distance from the objects to be radiographed, hence greater sharpness and better definition are obtained. For medical purposes there is still much to be done by way of improvement. One of the chief drawbacks of the tubes as at present used is that, owing to their shortness, sparks are liable to brush from the terminals and to touch the patients. To overcome this defect I have designed a special tube, which is perfectly insulated for such a length as to render this accident impossible. The tube in question serves its purpose (so-far) very well. This brushing from the terminals is disadvantageous from two points of view. In the first place, it is painful; and in the second, it is liable to make your patient jump to such an extent as to imperil the safety of your tube.

The electrical portion of the necessary apparatus, we are informed, is capable of little improvement, hence further advances lie to a great extent in the hands of the photographer,

whose energies should now be devoted to perfecting his methods so that the best possible results can be obtained. As most of the enthusiasts who have taken the matter in hand are amateurs, and as to the investigations of these we owe the unparalleled progress of the science and art of photography, I cannot but feel that the progress of radiography could not be in better hands.

Considering the fact that during the few weeks which have elapsed since the first news of Röntgen's discovery reached us, the rapid strides made are little less than marvellous. The exposure necessary to give a good negative of the bones of the hand, for instance, has been reduced from sixty minutes to a less number of seconds.

The pictures now produced can in no sense of the word be considered as shadows, for they present a wealth of detail which was in the earlier experiments not anticipated. It has been found possible to pass the rays through every portion of the body; and although (at present) when dealing with the thicker parts the negatives are far from perfect, and compare very unfavourably with those obtained from the extremities, even these are better in many respects, than some of the first published productions from the thinner parts. The chief difficulties at present in the way of producing good negatives of the thicker parts—viz., distortion, and want of detail—arise from our inability to bring the bones in these parts sufficiently near to the sensitive surface to produce sharpness in the image. By the use of photographic films, which can be bandaged upon the limbs, this difficulty is to a small extent obviated, and with the introduction of more perfect tubes it will be overcome, as they will allow of their being used at a greater distance, without its being necessary to give an inordinately lengthy exposure. The distortion, which is most marked when a small apparatus is used, is due to the spread of the **X** rays caused by the necessity of using the tube in close proximity to the part to be radiographed. I say necessity, because were the

tubes placed at such a distance as to render the image sharp, the exposure would become so lengthy as to render the operation, to say the least, exceedingly irksome to the patient.

Another difficulty, though not an insurmountable one, arises in the giving of a proper interpretation of the results obtained. Radiographs differ from ordinary photographs in that, instead of being surface presentments, they picture all the details in the structure of the object radiographed, greater prominence being given to those contained in that portion of the structure which is placed nearest to the photographic plate. Inasmuch as they give detail in addition to outline, they cannot be considered as shadows, as a shadow represents only the form of a body which intercepts rays of light. That the X rays are not light rays, in the ordinary acceptation of the term, has been amply demonstrated; neither do the terms "transparent" and "opaque" apply to them, for in my belief no substance will stop them, granting that a sufficiently lengthy exposure be given. That some substances retard their passage to a greater extent than others is obvious, or it would be impossible to obtain an image of bone. That bone however is transparent is demonstrated by the fact that a needle, or other foreign body, can be radiographed through it. Going a step further, it can be demonstrated that a needle is transparent by radiographing another body through its substance.

The production of radiographs depends then not upon the fact that some bodies are opaque, whilst others are transparent to the X rays; but upon the demonstratable principle that some substances allow them to pass through more easily and quickly than others. Hence photographic experience and skill play an important part in their production, inasmuch as they enable the operator to judge the exposure to such a nicety as to ensure the obtaining of a required result.

The above-mentioned difficulty of properly interpreting the results obtained will soon disappear with increased experience, and no doubt many new facts will be discovered. Of the many

suggested applications of radiography none bid to equal in benefit those which even at this early stage of investigation are likely to accrue to the surgeon. In the very earliest experiments it was predicted by those who could grasp the full significance of the discovery, that surgery was likely to receive considerable help at its hands, but to none did it occur that such rapid strides would be made in this direction in so short a time. In an article which appeared in the March issue of *The Practitioner*, by Albert Carless, M.S., F.R.C.S., it is stated that Mr. Porter, of University College, "doubts whether it will ever be possible to do much with the bulkier parts of the body, such as the legs above the ankles, and therefore the use of this process in practical surgery must be very limited." This statement is a glaring example of the error of forming an opinion too hastily, for almost before the issue was placed in the hands of its readers, the possibility of radiographing the spinal column, and through the skull, had been practically demonstrated, whilst knee, elbow, and shoulder joints are perfectly rendered.

Its usefulness to the surgeon has daily increased since the appearance of this article, and at the present moment all who have sought its aid in the diagnosis of suitable cases, and who have taken the trouble to satisfy themselves of the progress made, speak in no measured terms of its future possibilities and usefulness. The discovery, in any part of the body, of a foreign substance whose density to the rays is greater than that of bone, is a matter of absolute certainty. The number of needles, bullets, fragments of metal, and portions of glass which have already been located is truly astonishing; and we cannot help wondering how, before Röntgen's discovery, so many persons managed to exist with such a heterogeneous collection of unconsidered trifles lodged in their tissues. The location of foreign bodies, although at present the most certain of the applications of radiography, is by no means the most important. We are enabled to locate with great accuracy the extent of injury caused by many diseases of bone; and in many instances

the very commencement of bone lesions is capable of demonstration. In diagnosing the actual state of affairs in fractures, radiography will sooner or later displace all other methods, for not only is it quite unnecessary to pull about the injured limb, which, to say the least, is an exceedingly painful process; but, no matter what amount of swelling is present, the photograph will show with absolute certainty the position of the fracture, and the amount of displacement. The same remarks apply equally to dislocations; and, moreover, in both instances the position of the parts can be ascertained after the splints have been applied, granting that the splint used is not a metal one.

In crushed limbs, where the injury to the soft parts is so extensive as to render it difficult to discover the state of the bones by the ordinary methods, radiography will be found of great service.

In tubercular osteitis, the limits of the disease can in most cases be clearly defined; and in suspected osteo-sarcoma, a doubtful diagnosis can often be made absolute.

As far as bone lesions are concerned, the old methods of diagnosis will have to be replaced by radiography, and its extended application cannot fail to stamp out the work of the "bone-setter."

In veterinary surgery it will undoubtedly prove very useful, many vexed points being capable of settlement.

I need have little hesitation in saying that Röntgen's discovery constitutes one of the most important advances (from a surgical point of view) of the century, and in predicting that increased knowledge is certain to extend the sphere of its usefulness.

I will now quote a few cases which have come under my personal notice, upon which radiography has thrown considerable light, and has materially aided the diagnosis.

Osteo-sarcoma of Humerus.—This case was brought to me by Dr. Winter, of Wolverhampton. Y. Z., a man of 26 years of age, whilst employed at his usual work, felt a sudden and acute

pain in his arm. This continued during the whole afternoon, but did not hinder him at his work. Whilst walking home he passed some waste ground, upon which the not uncommon game of throwing at cocoa-nuts was being indulged in. Thinking that perhaps a little exercise would tend to remove the pain, he took up a ball, and whilst in the act of throwing it, his arm fractured at the junction of the middle and upper thirds. He went straight to the hospital, where the fracture was reduced and was put up in splints. After three weeks a plaster of paris case was applied; and some six or eight weeks later, the arm appearing to be perfectly well, he resumed his work. After a short interval he experienced some pain, and a hard round swelling appeared round the humerus at the point of fracture. This continued to increase in size, and finding it impossible to work, he again applied to the hospital. The history of the case, together with the character of the enlargement, naturally suggested the presence of sarcoma; as, however, some diversity of opinion existed, the man was sent to me. The radiograph cleared up two important points. In the first place, it showed that no callus had been thrown out; and in the second, that the bone in the immediate region of the fracture was soft, and allowed the X rays to pass through with great ease. The diagnosis now being made certain, the limb was amputated, and subsequently the state of affairs pictured in the radiograph was verified.

Fracture of Metacarpal Bone by Bullet.—(Fig. I.) In this case, which was brought under my notice by Dr. S. H. Agar, of Henley-in-Arden, a young man whilst handling a revolver accidentally shot himself in the palm of the hand. The radiograph, in addition to showing the exact position of the bullet, proved the existence of a fracture of the metacarpal bone, which had been previously overlooked on account of the amount of swelling which ensued. The bullet was removed with the greatest ease by Mr. Gilbert Barling, F.R.C.S., who acknowledged the help the radiograph had rendered him.

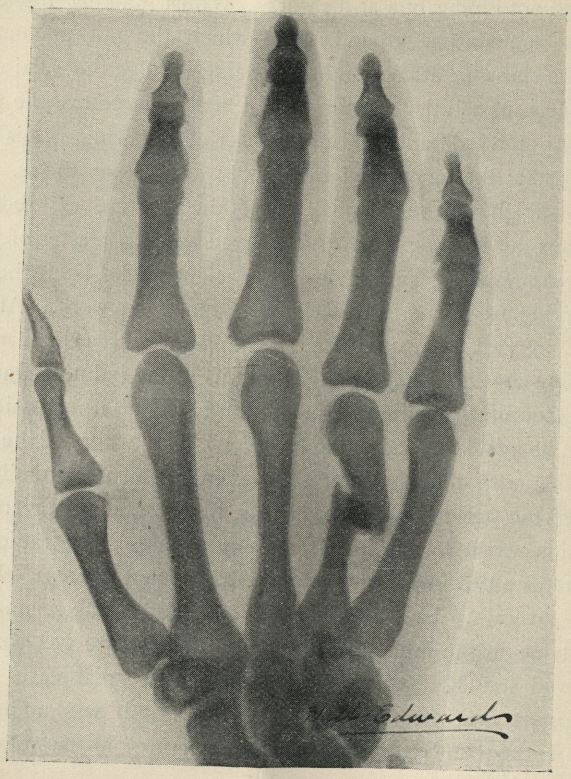

Fig. I.

Tubercular Osteitis of Metacarpal Bone.—(Fig. II.) The boy whose hand is here reproduced was under the care of Mr. Gilbert Barling, F.R.C.S., at the General Hospital. The radiograph shows plainly the diseased area; the inflamed portion of bone having a distinctly different appearance from the normal. In cases of this kind, where the circumscribed diseased area can be mapped out, the pictures must prove exceedingly useful when any operative procedure is thought advisable.

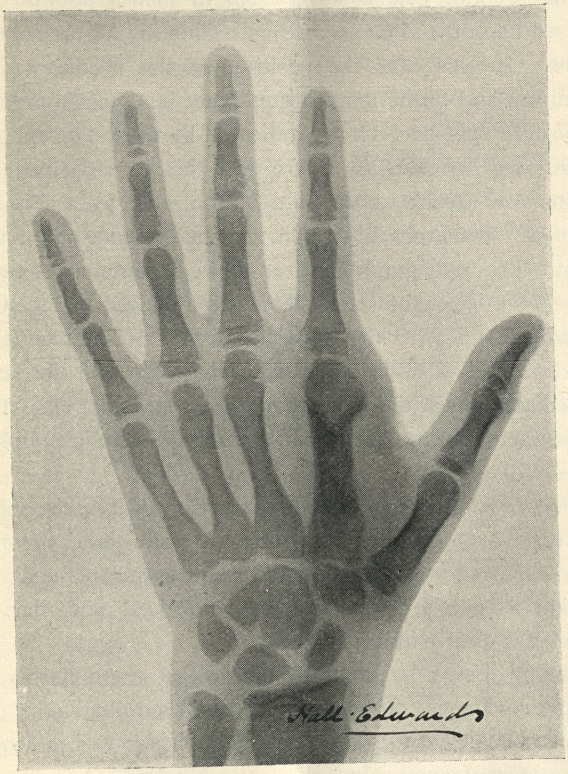

Fig. II.

Needle in Forearm.—Case under the care of Mr. Frank Marsh, F.R.C.S., at the Queen's Hospital. Four years previously this woman whilst scouring the floor broke a needle into her arm just above the wrist. Lately she had complained of great pain in the elbow, and as it was quite possible that the needle had worked into this region, she was sent to me. A radiograph of the elbow failed to discover its whereabouts, but one of the wrist showed it plainly in the exact position in which it was stated to have entered. The interesting part of the case consisted in the facts that in the first place the needle had entered the bone, and

in the second, that it was placed in such a position that it pressed upon the ulnar nerve, thus accounting for the pain in the elbow. In this case the position of the needle was quite unknown, and furthermore it could not be detected even when its position had been clearly indicated by the radiograph.

Fragment of Steel in Wrist.—In this case the man whilst forging was struck at the side of the wrist by a chip from a hammer. The probe failed to locate the presence of any foreign body. The radiograph however showed the exact position and shape of a piece of steel. This was removed by Mr. George Heaton, F.R.C.S., at the General Hospital. The fragment was found in the position indicated, lying beneath the tendons immediately over the semilunar bone; and after extraction its shape was found to exactly correspond with the image pictured in the radiograph.

Necrosis of lower end of Radius.—In this case the softened and vascular bone tissue is distinctly visible, and the periosteum appears to be infiltrated with calcareous material. The position from which a small piece of dead bone has been removed is clearly indicated.

I might quote a large number of cases where positive and negative evidence, of great value, has been obtained, but the above are sufficient to prove that the application of radiography to surgery is of some value.

Many of the most interesting results obtained through the thicker parts of the body, whilst amply sufficient for purposes of diagnosis, are, from a photographic point of view, not sufficiently good to stand reproduction. However, the two simple cases here illustrated clearly point to the fact that the surgical applications of radiography are not so restricted as it was at first imagined they would be, and that its future possibilities are great. I would that I could give you more illustrations, as they would undoubtedly carry more weight than anything I can write; but, unfortunately, the cost is too great to allow of it.

The most important question I shall be asked by the readers

of this article is—Will it ever be possible to differentiate the soft structures and to localise growths other than those of bone? Judging from certain results, accidentally obtained, I am almost persuaded to answer in the affirmative; at any rate, I am certain that we have arrived at present only in the borderland of the vast field open to us, and that experience, and improved apparatus, will greatly enlarge the scope of the application of radiography. It is impossible to predict with any degree of certainty its ultimate usefulness. Improvements in technical details are sure to produce more serviceable results, and that these will come we need have little fear. Further advances lie to a great extent in the hands of the physicist and photographer, and discoveries in directions which do not come within the scope of practical surgery may, ultimately, prove of the greatest value to the surgical radiographer.

The principles involved in the action of the **X** rays upon the sensitive surface of a photographic plate are so obscure, and ill-understood, that considerable difficulty stands in the way of very rapid progress in this direction. The various theories put forward to account for the phenomena are too lengthy for discussion here, and, moreover, they do not come within the province of this journal.

Apart from actual photography, by means of the **X** rays another method of diagnosis is placed in the hands of the surgeon through their instrumentality. I refer to the use of the fluorescent screen. This consists of a wooden frame covered with some thin but opaque medium (black paper, cardboard, aluminium, celluloid, vulcanite, etc.), one surface of which is dusted over with some fluorescent substance preferably potassium platino-cyanide. When such a screen is brought near a Crooke's tube in action, the fluorescent surface being turned towards the observer, a bright coloured light is emitted from its surface, and if a limb be placed between it and the Crooke's tube, the bones become plainly visible. The tube itself should be encased in black paper, so as to exclude the fluorescent flicker from the surface of the glass; all other extra-

neous light must also be excluded from the room. By the aid of the fluorescent screen we are enabled to actually see through the body, and to localise the presence of foreign substances. Although in my opinion the usefulness of the fluoroscope bears no comparison with radiography, there are occasions when it is likely to prove exceedingly useful. After a considerable number of experiments with fluorescent screens, I have failed to see anything approaching the amount of detail which is shown in a radiograph, and considerable improvement will have to be made in their construction before in most cases they can satisfactorily compete with the photographic plate.

In the case of a foreign body being lodged in the trachea or gullet, the screen would undoubtedly prove of great service, not only in showing its position, but the progress and position of the instruments used in extracting it could be watched during the operation.

The question of the relative transparency of the various tissues of the body is one that cannot be lightly passed over, inasmuch as the future possibility of radiographing soft growths depends upon it. That the soft structures differ from one another in their power of obstructing the rays we have ample evidence, many of the more bulky ligaments and tendons being plainly visible in the photographs. It is possible that improvements in various parts of the apparatus may enable us to make differentiations which at present are impossible. Cartilage and fat appear to be the most transparent tissues, and it has been proved that the cortex of the kidney allows the rays to pass much more easily than the pyramids. The length of the exposure given to the plate has much to do with the rendering of differences in the tissues, and nothing but experience and practice will enable us to obtain a proper command of the forces at our disposal. This point is clearly exemplified in the fact, that writing and printing do not as a rule show up; whereas if proper precautions be taken it is quite possible to radiograph the writing upon a sheet of paper, through an envelope.

The proper interpretation of radiographs is not an easy

matter, and much experience is required to enable one to do this satisfactorily. In the detection of foreign bodies, the position, looking in the direction in which the rays have passed, is patent to the most inexperienced; but it is a matter of considerable difficulty in a large number of cases, to judge with anything approaching accuracy, the depth at which the body lies. In some cases it is difficult to decide at which side of the bone (front or back) the body is situated. This question, and indeed the exact position, can frequently be proved by radiographing the limb from two aspects. Given a needle in the sole of the foot, for instance; a radiograph taken right through (the tube being placed above the foot and the sole resting upon the plate) will prove its position in one direction only. To decide its exact location it is necessary to take a second picture, the foot being placed sideways upon the plate. The position of a foreign body in the hand can often be accurately judged by radiographing from both sides and comparing the sharpness of the two images. The nearer a body is to the plate, the sharper its image will appear.

An extended investigation with the object of ascertaining the differences in appearance of various pathological specimens, the exact diagnosis of which has been confirmed, cannot fail to add much to our knowledge, and will render us better able to judge the condition of things in the living body. It was at one time thought that the **X** rays might differentiate between living and dead tissues, but this has been proved to be incorrect, as they are both equally transparent.

As an example of the difficulty sometimes experienced, I, a few weeks back, radiographed a case of tubercular disease of the elbow-joint in a child. The print showed all round the joint a confused mass of dark patches, which were evidently much more opaque to the **X** rays than the bone itself. I was much puzzled to account for this curious appearance until I learned that the disease had been treated with injections of iodoform emulsion. On experimenting, I found iodoform to be exceedingly opaque, a long exposure being necessary to get

the rays through even a thin layer. The knowledge of this fact may prove very useful. The blood vessels of pathological specimens, for instance, can be filled with emulsion, when a radiograph of their ramifications can be secured. Again, given a sinus the exact course of which we wish to ascertain, it would, in some cases, be an easy matter to fill it with some opaque material prior to taking a radiograph; and many other conditions are sure to confront the surgeon in which such injections may render much assistance.

With improved tubes I see no reason why we should not be able to diagnose stone in the kidney, indeed, granting that the stone is a large one, there would be little difficulty with a long exposure (30 or 40 minutes) in doing so now. A stone in the bladder would present greater difficulties on account of the thickness of the bones of the pelvis, but even this might be overcome in the full bladder by so placing the patient that the stone would occupy a position free from bony surroundings. The diagnosis of stone in the gall-bladder is indeed almost impossible, from the fact that cholesterine is an exceedingly transparent substance. The possibility of radiographing the brain is an exceedingly remote one, as not only is brain substance very transparent to the X rays, but the bony frame by which it is surrounded is comparatively dense. The position however of a bony tumour could (under certain conditions) be made manifest.

It is exceedingly doubtful if the presence of a sarcoma in the soft parts could (at present) be diagnosed, although in a pathological specimen I have succeeded in detecting a slight difference in the transparency of such a growth compared with that of the surrounding tissues; it is highly possible however that a fibrous tumour (on account of its greater density) could be made visible.

Glass, earthenware, and china are to a greater or lesser extent opaque to the X rays, hence their presence can be detected; splinters of wood, on the other hand, are so transparent that they cannot be detected with any degree of certainty.

So many erroneous statements have appeared, both in the lay

and scientific press, that I feel it my duty to contradict such as I have proved to be incorrect. It has been stated that the X rays have the power of killing the hair, and a case has been recorded in which a round bare patch appeared upon the head of a subject who seven weeks previously had been subjected to the influence of the rays. I have radiographed through the heads of several patients and so far no such effect has been produced. Again, I have (for experimental purposes) radiographed my own hands dozens of times, and I fail to see any difference in the growth of hair. It has again been said that the reason the eye cannot perceive the rays, is due to the fact that the lens is opaque to them. I find the lens to be very transparent; indeed much more so than the sclerotic coat. That the X rays kill bacteria I think is more than doubtful; indeed one investigator states that after submitting twelve varieties to an hour's exposure he found them more lively than ever. Many other rash and erroneous statements have been made and repeated, but no others which touch upon the medical or surgical applications occur to me.

Some time since I had the pleasure (through the instrumentality of this Journal) of advocating the claims of photography as a hand-maid to the sciences of medicine and surgery, and now that Röntgen's discovery has widened the scope of its application, I can only emphasise the remarks I then made, and shall trust that our surgeons will not be slow in recognising the fact that a photographic record of the cases which present themselves at our large hospitals, is as much a necessity, as the taking of notes. In the photographic plate—which has been called by a French astronomer "the retina of science"—we have a means of obtaining accurate records, which, had they always been kept, would have settled many a vexed point, and would have provided for all a means of gaining knowledge, of inestimable value.

That every large hospital will sooner or later have to be provided with the necessary apparatus for obtaining radiographs, is certain; for as our knowledge of the properties of the X rays increases, their usefulness as a means of diagnosis is certain to

extend. To the Army surgeon in the field, radiography must prove of the greatest use, not only from a humanitarian point of view, but from the fact that its practical application would save much time, and the location of bullets would be made a matter of absolute certainty.

It is perhaps necessary for me to explain why I use the term "Radiography" in preference to that of "Skiagraphy," which has been generally adopted by the medical press. In the first place, most of the scientific journals and all the photographic ones have adopted "Radiography;" in the second, as I have before pointed out, the pictures produced are not, strictly speaking, shadows; in the third, the term "Radiography" conveys no theory other than the generally accepted one, that the photographs are produced by radiations; and lastly, even in the face of its being a mongrel word, it is more scientific and euphonious, and far more easy to remember, than its more classical but incorrect competitor.

[The blocks from which the illustrations have been printed, were made from untouched prints, untouched negatives; and although they have lost much detail in the process of reproduction, they are purely photographic, and free from hand work.]

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